SnapMove: Movement Projection Mapping in Virtual Reality

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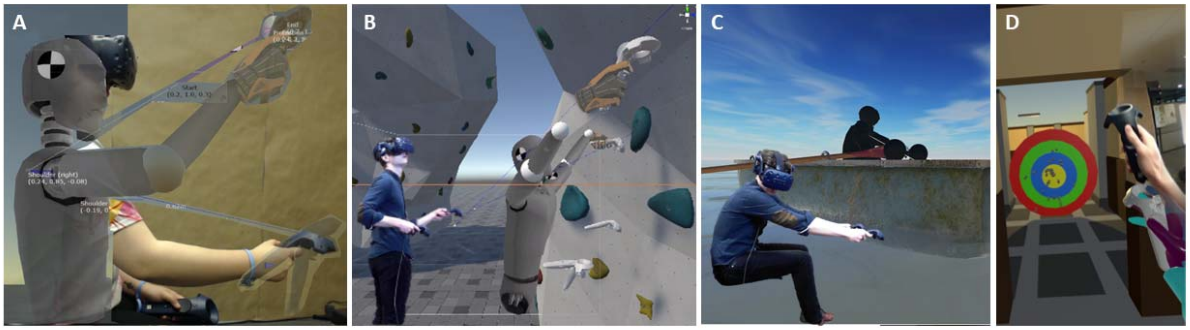


Figure 1. a) Participant embodied in a co-located avatar that has been remapped to a higher position. b) Participant climbing; with *SnapMove* enabled the user's hands can remain much lower than the avatar hands. c) Rowing scenario. d) Remapping with respect to a target can create the illusion of increased accuracy on tasks that require fine precision.

***Abstract*—We present *SnapMove* a technique to reproject reaching movements inside Virtual Reality. *SnapMove* can be used to reduce the need of large, fatiguing or difficult motions. We designed multiple reprojection techniques, linear or planar, uni-manual, bi-manual or head snap, that can be used for reaching, throwing and virtual tool manipulation. In a user study (n=21) we explore if the *self-avatar follower effect* can be modulated depending on the cost of the motion introduced by remapping. *SnapMove* was successful in re-projecting user's hand position from e.g. a lower area, to a higher avatar-hand position—a mapping which can be ideal for limiting fatigue. It was also successful in preserving avatar embodiment and gradually bring users to perform movements with higher cost energies, which have most interest for rehabilitation scenarios. We implemented applications for menu interaction, climbing, rowing, and throwing darts. Overall, *SnapMove* can make interactions in virtual environments easier. We discuss the potential impact of *SnapMove* for application in gaming, accessibility and therapy.**

***Keywords*-Motion Remapping, VR, Embodiment, Visuomotor Illusion**

I. INTRODUCTION

One of the benefits of Virtual Reality (VR) is that users can interact with the digital content in a first person perspective: they can move around and reach out for objects [1]–[4], creating a natural interaction that enhances presence [5]. Yet, many prior systems have constraints on the physical embodiment and movement of the user in VR. For example, most systems include a virtual representation of the body rendered in the same location as the user's physical body [6], [7] or a one-to-one motion mapping of the user's movements. This presents challenges for wide adoption: full body movements can become tiring, and in some cases users might not have the ability to reach certain regions in the VR space. These limitations are present when users are in a restricted physical spaces or if users have motor disabilities that prevent their range of motion and articulation. In this paper, we present *SnapMove*, a 3-dimensional (3D) user interface technique that involves a **many-to-one** mapping, where multiple real postures map to a single posture in VR both in horizontal and vertical positioning.

Exploring a many-to-one mapping can reveal patterns of variation in users' strategies to reach a given position,which serves as a test of our scientific understanding of embodiment: how sensitive are users to the representation of their body and movements in VR? For one, users have been shown to minimize the spatial mismatch between their real and surrogate bodies [8], [9], as observed in the *self-avatar follower effect* [10]. At the same time, users try to find sensorimotor strategies to achieve a given outcome with the minimal energetic cost [11]. In this paper we implement the *SnapMove* technique, and test this interplay (minimizing mismatch vs. conserving energy) in a many-to-one mapping.

Overall, with *SnapMove* we present the following contributions:

- Propose a novel 3D user interface technique that uses reprojection to allow for many-to-one interaction mappings.
- Quantify the natural drift and energy requirements of different areas of the reachable space, and measure their interplay with the Follower Effect.
- Evaluate whether reprojection can be used to inflate the perceived accuracy on a motor task, with a subsequent enhancement of self-efficacy.
- A series of applications that are susceptible to reprojection, including: rowing, dart throwing, menu selection, with potential use in gaming, learning and physical therapy.

II. Related Work

A. *Real-to-virtual mapping techniques*

In regular VR environments, 3D positions in world-space are mapped to 3D positions in virtual space, where each point in the real-world, has only *one* corresponding point in the virtual world. Prior work has shown that this one-to-one mapping can be altered to create a new set of possible and useful interactions in VR (e.g., *Go-Go*, *Erg-O* the *Ownershift* techniques or motion retargeting in general).

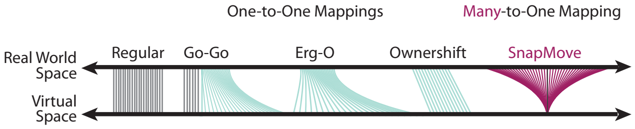


Figure 2. Schematic of the dimensional transformations that different techniques offer when it comes to augmenting regular one-to-one mapping in VR.

Go-Go, creates a pairwise mapping function to relate the user-to-hand distance to a larger peripersonal space through a form of exponential scaling in a one-to-one mapping: as you reach further away from your body, the positions remap much further, while near the body there is an exact match between position in reality and in VR (see Figure 2) [12].

Erg-O creates a generalized position re-targeting paradigm [13], where targets can move closer to the participant and are, hence, easier to reach (see Figure 2). Note that with Erg-O, the geometric mapping may deform as the target or the hand moves to different locations, but the property of it having a one-to-one mapping remains—for every point in real space, there exists only one point in VR, and vice-versa.

Ownershift maps users' hand positions (e.g., at waist-level) higher up (e.g., at eye-level), serving as a translation and rotation of the hand position and orientation in a one-to-one mapping (see Figure 2) [14]. This method can reduce the difficulty of longer input tasks (e.g., keyboard entry). The basics of this technique have also been implemented as position amplification/scaling in other forms such as [9], [15].

Taken together, *Go-Go*, *Erg-O*, and *Ownershift* serve as different examples of transformation techniques that maintain a one-to-one mapping in physical location. Recently, there is growing interest in exploring **many-to-one** mapping, where multiple real postures map to a single posture in VR, though prior work has only examined horizontal motion at the shoulder [10]. However, it remains unclear what the effect of vertical changes would be, which would create different levels of shoulder extension (and thereby different levels of fatigue). No prior work, to our knowledge, has implemented and tested visuo-proprioceptive mismatch in elevation in a many-to-one mapping in VR, as well. We address this gap in present paper with *SnapMove*, where we test many-to-one mappings for both horizontal and vertical motion.

B. *Self-avatar embodiment and follower effect*

With a many-to-one mapping correspondence, there are many novel scientific questions to address. For one, how do users respond when given a null space—that is, many options for their hand position to reach a single given virtual position? Recent work provided initial evidence that when participants are given a null space in VR, they tend to "actively compensate the spatial mismatch by moving the physical body to fit the virtual body location whenever the system allows for it" [10]. However, this work did not explore reaching permutations beyond a side-to-side motion. It remains unclear what the effect of vertical changes would be, which would create different levels of shoulder extension (and thereby different levels of fatigue).

Large spatial mismatches between the physical and virtual bodies have been shown to have a detrimental effect on ownership illusions [4]. At the same time, visuo-proprioceptive mismatch during motor actions can still be accepted by the users in VR if it is consistent to some degree [2]. For example users accept movements that are faster than their own [16], are smoothed over time [17], or are on a different scale [18]. However, when the mismatch is too radical this can induce a movement violation [19] and a break in body ownership [16]. Nevertheless, previous research has shown that users do not always notice spatial and temporal visuomotor mismatches [16] and easily accept adaptive spatial offsets as in the case of retargeting [20] and similar ad-hoc manipulations [14].

III. SnapMove Technique

Extending [10], we explore multiple reprojection modes and combine them into one technique: *SnapMove*.

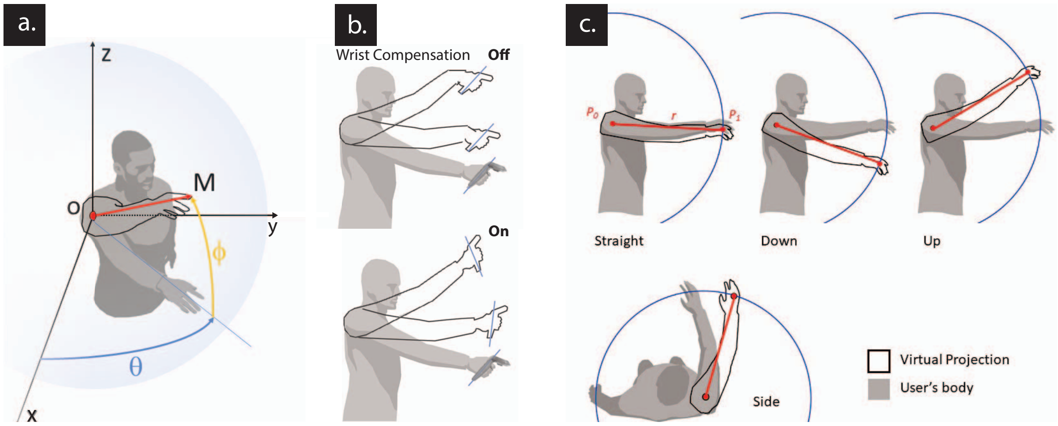


Figure 3. Visual overview of SnapMove projection and the different directions studied. (a) The hand position at a given point can be reprojected to another location in the 3D space, such that the avatar is at a different location than the real hand (in grey). b) We added a rotation compensation so the virtual controller orientation rotates linearly with the angle of deviation between the virtual and real arms, with respect to the shoulder. This is particularly noticeable when remapping beyond 10-15 degrees. c) For any position on the sphere, the avatar will appear at P_1. The avatar hand is projected onto a line drawn between the shoulder and the hand in gray—allowing the real hand to occupy any possible space along the sphere. Note that the radius of the sphere scales responsively with the reach r

Each of the modes has a particular application space and is ideal when the participant has a known target. *SnapMove* is not a scaling nor a non-linear bijective mapping—it is chiefly a reduction of dimensionality to a fixed line (a *surjective* mapping), where any reach posture with a given reach distance will project to the same spot (e.g. moving the hand side to side, and up and down, would not affect a change on the avatar, except for small motor noise visible from the avatar orientation).

A. Implementation

First, we design a null algebra space for the motor actions, where all the real hand positions map to a single point along a projection line or a plane. The projected position is based on the reach distance r, which is the absolute distance from shoulder-to-hand. Then in real-time we use inverse-kinematics (IK) to reconstruct the motion from the shoulder position and show the avatar in the desired spot. With the *SnapMove* we can re-project the positions of the avatar in real-time while the participant might or not be co-located with it and or doing motions in different directions, see Figure 3.

To implement *SnapMove* we compute the position reprojection and the wrist rotation compensation.

Position Reprojection Algorithm:

1) We define *projectionVector* as a unit direction from the shoulder *shoulderPos* towards the desired target.
2) Using the actual hand position, *handPos*, we calculate a second vector *handVector* = *handPos*-*shoulderPos*.
3) We calculate the projected position of the virtual hand onto *projectionVector*: *virtualHandPos* = *shoulderPos* + *projectionVector* ∗ *handVector.Magnitude*. This sets the virtual hand as far away from the anchor as it was in the original direction.

If we want to have an scaling effect, we can multiply the *handVector* magnitude by a scalar in Step 3. In cases where we need to introduce this effect gradually or don't want complete remapping, we can apply a linear interpolation between the projected position and the hand position after Step 3: *virtualHandPos* = *Vector3.Lerp(handPos, virtualHandPos, percentBlending)* where *percentBlending* $\in [0, 1]$.

1) Wrist Rotation Compensation: As the real hand and avatar hands drift apart, the orientation between the forearm and the controller has to be compensated from the real hand to the avatar. If there is no compensation large drifts lead to unnatural appearing wrist angles, Figure 3b. To address this issue, we apply a Rotation Compensation (RC) that calculates the drift the virtual hand position linearly with the angle of deviation between the fake and real arms, with respect to the shoulder. To compute the compensation for the hand rotation, we calculate the quaternion that will compensate for both dx and dy changes, in the following way:

```
rotComp = RC(handPos − shoulderPos, projectionVector);
projection.rotation =
 Quaternion.Lerp(handRot, handRot∗rotComp, percentBlending);

function RC(handVector, projectionVector)
    dx = Vector3.SignedAngle(
     new Vector3(projectionVector.x, 0, projectionVector.z),
     new Vector3(handVector.x, 0, handVector.z),
     Vector3.down);
    dy = Vector3.SignedAngle(
     new Vector3(0f, projectionVector.y, projectionVector.z),
     new Vector3(0f, reachVector.y, reachVector.z),
     Vector3.left);
    rotY = Quaternion.AngleAxis(dy, Vector3.right);
    rotX = Quaternion.AngleAxis(dx, Vector3.up);
    return (rotY ∗ rotX);
```

2) Linear Reach Projection: SnapMove projects the avatar position onto a line between the shoulder and a target, letting users reach perfectly without missing the target whereas their real hand can be anywhere else in the volume of their reach.

From the IK-inferred shoulder position, we draw a ray in a given direction. This 'projection line' defines where the avatar hand appears (Figure 3a).

IV. User Study

We designed a series of motor control tasks based on *SnapMove* to evaluate how well people accept reprojection of their motions in different contexts and how much the *self-avatar follower effect* [10] interacts with the new re-mappings in vertical and horizontal planes. In particular, we targeted four different areas of remapping (Figure 3).

We additionally tested reprojection onsets: introduced 1) gradually or 2) instantaneously. A gradual onset consists of adding increments to the projection of the avatar towards the desired target by a fixed amount of time over each motor interaction. In instantaneous projections, the avatar arm moves directly to the final energy projection, with no delay. Both types of onsets might have different applications. A gradual onset might be useful for subtle movements or physical therapy, while the instantaneous could be used to help avoiding a collision (e.g., a bystander or object that unexpectedly entered the VR play space when using VR in the wild [21]).

A. Participants

We recruited and compensated 21 right-handed participants (8F, 13M) between the ages of 18-65 (mean = 29 years)—all free from any conditions affecting movement or control of the upper limb. The level of experience in VR and gaming differed widely across participants, from first-time users to VR experts.

B. Procedure

Participants were seated, stationary and facing forward (towards $+z$) in a left-handed coordinate system. An HTC Vive Pro with two tracked controllers were driven by Unity at 90Hz used in this seated posture facing forward with feet on the ground. A small sphere with a collider was placed in the middle of each virtual controller for the user to hit a 'close' and 'far' target cube in the virtual environment. We use a robotic avatar with a matte-grey arm color, with a glove, and participants were asked to make their fingers align with the way the model held the controller. For calibration of the postures, we manually recorded the 3D position of the right shoulder's range of motion and fixed it for the course of the reaching experiment. We recorded reach length as the distance from the shoulderpoint to the center (3D origin) of the tracked controller so the close target was just in front of their shoulder and could be reached without fully flexing the elbow, or hyperextending the elbow for the far target.

1) Conditions: Overall, participants performed reach trials (of 20 reaches each) in each of 4 directions (**Straight, Down, Up,** and **Side**)—applied with an **instantaneous** or **gradual** onset (blocked; order randomly selected for each user). Note that in the **Straight** condition, we only apply it instantaneously, as the direction of the avatar's target does not change, resulting in a total of 7 conditions. Each of the seven conditions was performed 6 times in different, randomly-ordered blocks, totalling 42 blocks (about 50 total minutes).

For each condition, participants were tasked with colliding their controller's center-sphere with a cube that would bounce between two locations, close and far away from the shoulder, along a line. The direction of that line would always start directly forward (the **Straight** condition). First they would perform two 'warmup' reaches and then the projection would be engaged for the rest of that trial as defined by the condition and onset. Note that at this point, the user would have been accustomed to reaching straight, movement they chould continue and still see their hand move along the projection line.

In all cases, the re-projection allowed participants to extend their arm in any direction, and successfully hit the target, as the avatar hand is locked onto the line between P_0 and P_1 (Fig. 3c). The difference in reach angle between real and virtual movements allowed us to measure any drift observed. In Figure 5c we can see a participant whose hand drifted significantly from the avatar's position.

2) Proprioceptive Assessment: After the last reach of each trial, participants were audibly reminded to 'freeze' until they indicated (i.e. guessed) the elevation of their hand. We disabled the avatar model and participants could control the virtual height of a virtual horizontal plane (using the left controller) (Figure 4). We asked participants to move the platform until they felt their real hand would 'rest on its surface', then lock in their choice with a press of the touch-pad. Proprioceptive error was a calculated by subtracting the real hand elevation from the guess elevation [22].

3) Embodiment Questionnaire: After every proprioceptive guess, participants evaluated their sense of embodiment in the avatar with one of the following questions extracted from [23]:

1) "I felt embodied in the avatar during the reaching task."
2) "I felt like I had two bodies during the reaching task."

3) “I felt satisfied with the interaction during the reaching task.”

After each trial, and within the VR environment, participants would respond on a Likert-scale from *strongly disagree* (-3) to *strongly agree* (+3). We aggregate them as $Embodiment = Q1 - Q2 + Q3$, and then perform a z-score normalization to get the dynamic range and normalize the intra-subject variability. Note that in each block we only asked the same question.

C. Measurements

1) Drift: Based on prior research we expect that, when performing an energy consuming motor task in VR, people will fatigue, ultimately drifting towards lower energy cost areas of the null space (the space created by virtue of mapping many positions to one). To test this prediction, we measured the drift of participants over the total of their reaches. The drift was calculated as illustrated in Fig. 5a-b.

For each forward reach, we first compute
$\theta_{\text{reach}_i} = \arctan(\frac{\text{SE}_y}{\text{SE}_z}) * \frac{180}{\pi}$.
where the SE_y is the change in controller elevation (y axis) from the Start point (S), to End point (E). While SE_z is the distance covered in the forward direction from the controller (z axis).

Next, we calculate **drift** as the mean θ_{reach} over the last 12 reaches, in units of degrees. Reaches in the range of 5-16 were more stable and support a more fair comparison between instantaneous and gradual onset conditions.

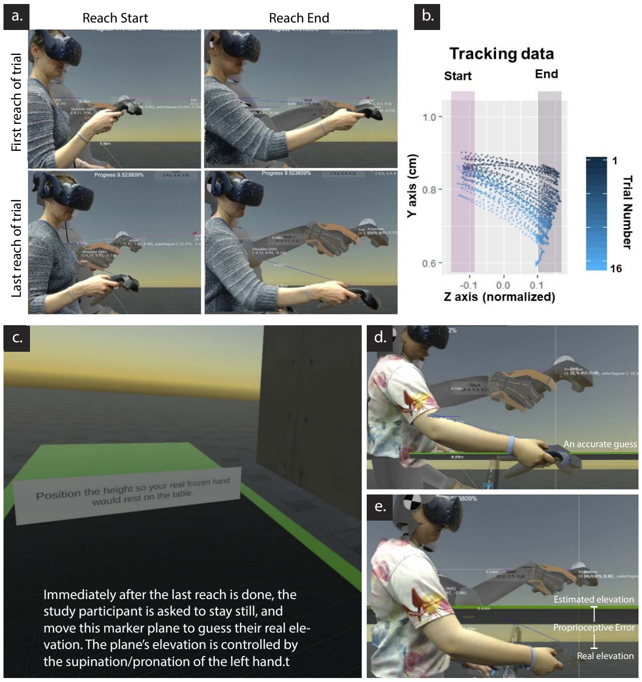
$drift = \frac{1}{k}\sum_{i=1}^{k}\theta_{\text{reach}_i}$

2) Proprioceptive Assessment:

D. Reaching Task Results

1) Straight Condition: In a short amount of time (about 20 seconds) we could visibly see how reaching behavior can drift toward lower elevations during a forward reach task (**Straight** condition, Figure 4a and b). Through the last 12 forward reaches, the difference between the avatar’s hand and the real participant hand showed a significant drift of $-4.8°(\pm 6.3° SD)$ (One-sample t-test $p = 0.002, t = -3.4, df = 20, 95\%$ confidence interval $[-7.7°, -1.9°]$, Figure 5c). Although this task is not particularly exhausting, we observed a strong drift effect.

2) Side Condition: In order to see whether participants try to follow and match the virtual avatar during the performance of motor actions, we created the **Side** condition, which showcased similar fatigue and energy cost mechanics as the **Straight** condition. We found significant effect of onset type, i.e. a difference in the horizontal **drift** between gradual ($mean = 0.2°$ sd=7.9°) an instantaneous onset ($mean = -6.9°$ sd=9.2°) (Welch Two Sample t-test $t = 2.7, df = 39.16, p = 0.009$), where a negative drift means the real hand did not completely follow the projection all the way to the right. Participants follow the avatar to a larger extent when the Side-directed projection is introduced gradually, rather than instantaneously (Figure 5e). There was no significant difference in vertical drift between the gradual and instantaneous onset conditions (t-test $t = 0.19, df = 39, p = 0.8$). This is consistent with the behaviours described in the self-avatar follower effect theory [10].



Immediately after the last reach is done, the study participant is asked to stay still, and move this marker plane to guess their real elevation. The plane’s elevation is controlled by the supination/pronation of the left hand.t

Figure 4. Reach trials and proprioceptive assessment. a) During a forward reach task (Straight condition), participants typically drift toward lower energies region, within a short amount of time (20s). The figure shows the case of a participant with a particularly large drift (b). d) Blind assessment of the hand position. While in some cases, the participant reported an accurate guess on where the hand was (e), in other they perceived their hand to be somewhere between the real and the virtual (f). The reporting was done by moving a platform (d) that would rest just below their hand.

Note the similar behaviour on the vertical drift between the **straight** condition (Figure 5c) and in the **side** condition (Figure 5e). Participants appear to be complicit with a similar degree of vertical mismatch between the avatar arm and their own of about 10 degrees.

3) Up and Down Conditions: We ran a repeated measures ANOVA with drift, accounting for two factors: Energy Cost with two levels (Up and Down), and Projection Onset, also having two levels (Instantaneous and Gradual). We find a main effect for Energy Condition ($p = 0.0005, F_{(1,76)} = 13.4$), showing that participants in

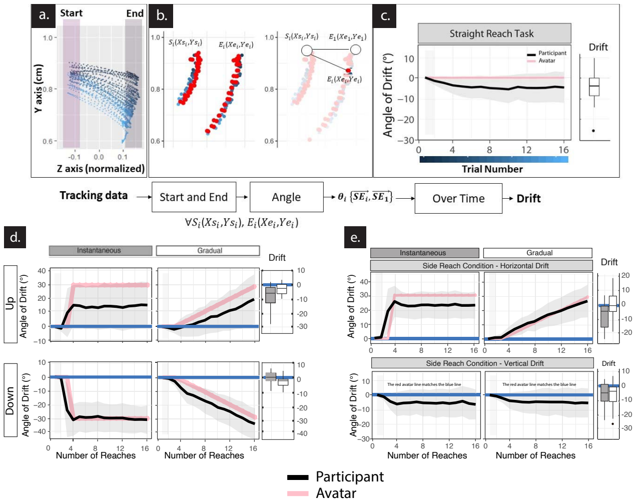


Figure 5. (a) In a short amount of time (16 reaches over 20s) the participant drifted to lower energies during (**Down**). (b) We calculate the drift angle (start - end) for each reach. (c) Mean drift across participants for **Straight**. (d) Drift in the **Up** and **Down**, for instantaneous and gradual conditions. Participants more closely followed the avatar hand when it went down, than when it went up. (c) The gradual condition led to more drift in the conditions. (e) Mean drift (verical and horizontal) across participants in the **Side**.

the **Up** condition (Gradual: $mean = -7.41$; sd= 12.75, Instantaneous: $mean = -15.60$; sd= 16.55) did not showcase such a strong self-avatar follower effect than in the **Down** condition (Gradual: $mean = -6.09$; sd= 9.91, Instantaneous: $mean = 0.08$; sd= 10.45), where they tended to match more closely the avatar posture (Figure 5d). There was a weak trend of interaction between Energy Cost and Projection Onset ($p = 0.08, F_{(1,76)} = 3.1$). In a post-hoc paired analysis we found that only for the **Up** condition was the **drift** significantly higher for the instantaneous than for the gradual onset ($p = 0.039$; *mean* and sd reported above). No significant effect of Projection Onset with the down condition was observed ($p = 0.1$). Data for this analysis had homogeneity of variance (Levene's Test $p > 0.12$).

E. Proprioceptive Guess Results

Reported median embodiment was higher when projection was applied gradually, than in conditions where it was applied instantaneously (in the Side, Up, and Down conditions). The accuracy of the proprioceptive guess was highly correlated with the **drift** measured for the same trial (Pearson correlation $cor = -0.64, t = -3.6, df = 19, p = 0.001$, Figure 6), but this correlation did not exist for the **Up** condition ($cor = -0.15, t = -0.7, df = 19, p = 0.4$).

1) Embodiment Results: Participants reported higher embodiment when they underwent a gradual onset projection than with an instantaneous onset (Figure 7). Wilcoxon signed rank test revealed a significant difference between onset types ($V = 47, p = 0.029$). This is in agreement with previous findings on semantic violations of movements [19] and with the self-avatar follower effect [10].

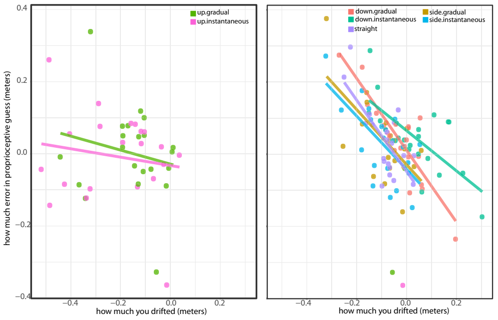


Figure 6. The correlation of the proprioceptive guess versus the drift was significant for all conditions (with instantaneous or gradual onset).

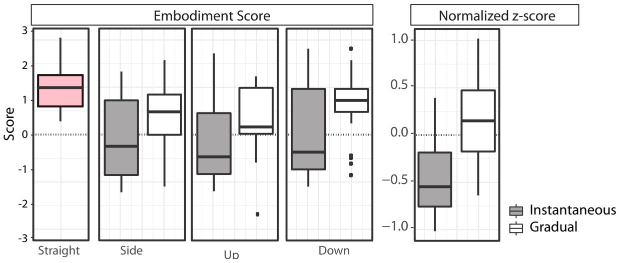


Figure 7. The embodiment illusion was significantly higher when the movement projection was introduced gradually than when the projection was instantaneous.

V. Discussion

In this paper we present *SnapMove*, a technique to flexibly remap participants' body-movements both horizontally and vertically in VR. This work serves as an extension of recent work examining many-to-one mapping finding a 'follower' effect for horizontal positioning [10]. Our results suggest that when users are embodied in an avatar and their actions are redirected in space through *SnapMove*, they tend to both horizontally and vertically converge towards the avatar. Users appear to exploit the null-space of the remapping (many real positions remapped onto a single virtual counterpart) for minimizing the spatial offset between physical and virtual body. This behavior is driven by the need to minimize sensory conflict associated with embodiment, and at the same time is a means to sustain embodiment. In line with previous studies, we also find a correlation showing that the more distance they exhibited towards the avatar, the greater was their propioceptive drift.

Here, we found that users tended to believe their hand was actually at the location of the avatar, suggesting the many-to-one mapping led to a flexible embodiment experience.

Furthermore, we found evidence for a trade-off between minimizing visuoproprioceptive mismatch [8]–[10] and the optimization of the energy cost and fatigue. Tasks that required more effort had a weaker 'follower' effect; users did not compensate for the visuoproprioceptive mismatch for more difficult reaching directions (e.g., **Up**). At the same time, users *did* 'follow' (i.e., become anchored) towards their virtual bodies for less demanding directions (e.g., **Down**). Taken together, these findings suggest a trade-off between fatigue and minimization of sensory conflict.

A. Accessibility and Rehabilitation

Our results have particular implications in the space of accessibility and rehabilitation. The remapping of motor actions through projections in VR applications can help proctoring rehabilitation tools and removing accessibility impairments [24], [25].

The user study also showed that instantaneous offsets favoured the minimization of fatigue, while the gradual offsets induced more self-avatar 'follower' effect instead. This is an interesting outcome as different applications would likely need to produce different levels of 'follower effect'. For example, rehabilitation applications where the aim is to gradually push patients towards more complex movements, a gradual onset will be more effective. In those cases having a stronger self-avatar follower effect can help pushing patients to gradually perform motor tasks in less used regions of their workspace, increasing their range of movements.

B. Real-world applications

Projection is a new tool to help support users who may have otherwise impaired motor function; in the case where they cannot reach the real-world pose of the target, *SnapMove* can be combined with with traditional scaling to allow grasp onto handholds beyond their *real* reach, all while maintaining some semblance of body ownership. An example of this reach projection is a climbing scenario (Figure 1). When the hand is retracted far enough, the projection vector simply re-aims toward the next handhold. We highlight a selection of application and game vignettes we have designed in Supplemental Video S1.

VI. Limitations

Further research on how *SnapMove* technique would combine with user input for manipulating the reprojections will be necessary. Gaze interaction modes could also be combined to account for further freedom in the projections. For example in the Climbing application participants might direct their gaze to define their next reach target. We show how gaze was already quite successful at reaching for a menu application. In fact we anticipate that *SnapMove* technique can be easily generalized with the arrival of accurate eye gaze detection systems integrated into HMDs [26], with which gaze direction can be used to select the target towards which re-project is done. However, we warn that extra freedom in selecting the trajectories based on the user input, specially if onsets need to be instantaneous could come at the cost of lowering the embodiment illusion on the avatar.

More high-dimensional and bi-manual mappings should be explored to identify the limit of how far dimensionality can be restricted before it no longer exhibits the follower effect, for example, by incorporating a reprojection of some of the controller orientation dimensions into a lower subspace, or by creating a bi-manual task where one of the hands is reprojected more severely than the other. Furthermore, we used a low-fidelity version of an arm and hand that was very simplistic—this raises interesting questions about whether a higher fidelity model would coincide with a stronger effect [27]. A study that explores the finer thresholds of the follower effect could also benefit from permuting the level of avatar realism.

VII. Conclusions

We present *SnapMove*, a technique to remap participants' body-movements inside Virtual Reality. *SnapMove* breaks the traditional one-to-one relation between the user's body and its first person avatar by snapping the avatar's hand to a predefined trajectory. This can help participants interacting in VR throughout the whole reachable space acting in a smaller region and without getting tired. For users with motor limitations *SnapMove* allows them not only to overcome limitations in their range of movement, but also to increase their accuracy in target tasks. Both cases can be useful for rehabilitation and accessibility purposes.

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